Weber, J. and Sultana, S. (2008). Race, Employment Sprawl and the Journey to Work in Birmingham, Alabama. Southeastern Geographer, Vol. 48 (1), pp. 53-74.
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Employment Sprawl, Race and the Journey to Work in Birmingham, Alabama

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Studies of residential sprawl have shown that longer commutes are typical for residents of these areas, but the effect of sprawling workplace locations on journey to work patterns has not yet been closely examined. This paper uses commuting data from the 1990 and 2000 Census Transportation Planning Package to examine the impact of employment sprawl on commuting, and its differing impacts on black and white workers within Birmingham, Alabama. This analysis finds that workers who commute to sprawling areas travel shorter distances, often spend less time commuting, are less likely to drive alone, and are more likely to bike and walk, though they do not earn as much as workers in urban areas. This suggests the possibility that workers may be able to reduce their commutes as more jobs relocate to sprawling areas. However, increased sprawl may result in increased commutes for black workers if they are not able to adjust their residential location, as shown by their longer commutes to jobs in sprawl locations.

KEY WORDS: sprawl, commuting, Birmingham, GIS

INTRODUCTION

Urban sprawl is a common characteristic of contemporary cities and growth processes in the United States. The land use patterns often characterized with sprawl (e.g. low density, leapfrog development) are associated with many externalities, such as a reliance on the automobile, resulting traffic congestion, and reduced mobility. Even though this association is obvious and seemingly irrefutable, this observation is, however, more commonly assumed than verified (Ewing, et al., 2003). It is still unknown whether observed increases in travel times, or differences in commuting times among cities, are directly the result of sprawl (Crane and Chatman, 2003).

This uncertainty about urban sprawl and its relationships to mobility exists despite intense scrutiny and debate due to a range of issues, including conflicting definitions of sprawl. Researchers often focus on residential sprawl measured by population growth (El Nasser and Overberg, 2001; Transportation Research Board, 2002; Tsai, 2005), and a few have extended this definition with consideration of land use mixes (Malpezzi, 1999; Galster, et al., 2001; Ewing, et al., 2003; Sarzynski et al., 2006; Cutsinger and Galster, 2006). Multiple scales of analyses can be an issue as well, ranging from metropolitan areas to counties, urbanized areas, neighborhoods, or residential subdivisions showing different aspects of commuting.

A debate also exists whether the relationship between urban sprawl and commuting should be measured using travel

distance or time (Sarzynski et al., 2006). If sprawl is represented by low density and fast growing population, then there is some evidence that sprawl or rapid urban growth is associated with longer commutes, whether measured by time or miles (Sultana and Weber, 2007; Sarzynski et al., 2006). However, whatever our knowledge of the relationships between sprawl and commuting time, this has come from studies based on residential sprawl. It is not just homes that sprawl, but offices, shopping centers, factories, and other places of employment. There has been even less empirical investigation of the impact of sprawling employment locations on commuting. Jobs scattered at low densities on the periphery of the city may have as much effect as residential sprawl in increasing commutes, and therefore, there are reasons for investigating this. It may be that the ultimate result of sprawl is a dispersal of homes and activities over the urban region with constant or lower average commute times.

Similarly any discussion of the relationship between commuting length and job sprawl is incomplete without integrating race, since the suburbanization of jobs imposes constraints on the spatial access to employment opportunities of Blacks living in central cities. This was first identified by Kain (1968) in the well-known spatial mismatch hypothesis. Since then race has been incorporated as a fundamental determinant of individuals' commuting experience (Zax, 1990; Gottlieb and Lentnek, 2001; Johnston-Anumonwo and Sultana, 2006). Blacks and whites have differing residential locations and commuting patterns, especially for suburban locations of jobs and even within cities (Sultana, 2005a; Horner and Mefford, 2007). Therefore, sprawling jobs may make for greater distances between jobs and home for black workers, as their highest concentrations can still be found in central cities.

This paper evaluates whether workplace sprawl makes a significant difference to commuting length or distance, as well as whether it has a significantly different impact on black workers than it has for white workers. The rapidly expanding metropolitan area of Birmingham, Alabama, which has had a strong history of racial residential and employment segregation, is used for investigating this issue. The remainder of the paper is divided into four sections. The first section provides a literature review on employment sprawl and commuting and the effect of race on commuting; the second section describes the study area, data, and methodology for mapping job sprawl; the third section presents the results by highlighting commuting patterns and differences between sprawl and urban job locations. A fourth section provides concluding remarks, detailed discussion and future direction of research.

LITERATURE REVIEW

Mapping Sprawl

It has become increasingly common to find sprawl index or rankings of cities (El Nasser and Overberg, 2001; Kahn, 2001; Transportation Research Board, 2002; Malpezzi, 1999; Galster, et al., 2001; Ewing, et al., 2004; Frumkin, et al., 2004; Tsai, 2005; Cutsinger and Galster, 2006; Sarzynski, et al., 2006). These usually are created at the metropolitan or county level, and allow cities to be placed on a continuum, with one end representing

sprawl and the other more compact urban growth. While the characteristics used to define sprawl include a variety of population growth, density, contiguity, clustering, land use mixing, and other variables, low density and rapid growth are two major components for a useful sprawl measure (Sultana and Weber, 2007).

However, there are fewer rankings for employment sprawl. One defines sprawl as the proportion of metropolitan employment located outside the central city (Gordon, et al., 2004), while another uses the proportion of employment located beyond 10 miles of downtown (Kahn, 2001) and a third uses a five mile radius as the threshold distance for sprawl (Stoll, 2005). These clearly do not allow for sprawl to be treated as a discontiguous spatial pattern, and treat sprawl essentially as a lack of centrality. They will also likely mix urban, sprawl, and rural areas, making the effects of sprawl impossible to define. Rapid job growth in outlying areas is not included, missing an important component of sprawl.

Mapping sprawl within urban areas has been less common, and has typically focused on population or housing patterns. For example, sprawl can be mapped as a low-density residential environment (Hasse and Lathrop, 2003) or a low density but fast growing population on the fringe of the city (Weber, et al., 2006; Sultana and Weber, 2007). The Urbanized Area (UA) is used to define the built up areas, as it is a census-defined zone based on contiguous census blocks that meet minimum levels of population density. This provides a consistent definition for identifying urban areas that ignores political jurisdictions or a problematic city/suburb distinction. With this definition sprawl can be mapped for Traffic Analysis Zones (TAZs), which are the smallest zones for which considerable information is available for multiple years, using the Census Transportation Planning Package (CTPP). Using this data sprawl can be mapped for any metropolitan area, and the relationship to commuting can be assessed (Sultana and Weber, 2007). Given that employment data are also available in the CTPP, job sprawl can be mapped in a similar manner to population sprawl, rather than ranking cities according to their level of sprawl. This approach treats sprawl as an urban growth process with high rates of job growth and low employment densities, and that takes place outside the built-up areas of the city.

Location of Employment and Commuting

Sprawl is heavily bound up in ongoing debates about the relationships between urban form and travel behavior, with the expectation that higher densities make for shorter work trips, a mix of transport modes, and vice versa. There are therefore strong expectations that sprawl will increase travel times and reliance on cars. At the metropolitan level, sprawl is typically measured as an index value for a metro area representing low levels of job centralization (Kahn, 2001; Gordon, et al., 2004; Stoll, 2005; Sarzynski, et al., 2006) or high rates of deconcentration over time (Crane and Chatman, 2003). If it is represented as the former, it will be expected to be associated with longer average metropolitan commutes, while with high rates of deconcentration it should be associated with increases in average commuting duration over time. The length of commutes is a crucial component in examinations of the

ability of households to carry out their daily lives efficiently. Long or increasing commutes can be indications of excess commuting, low jobs/housing balances, and spatial-mismatches (Sultana, 2002b, 2005a; Aguilera, 2005; Horner and Mefford, 2007).

Studies have found increases in commuting length with an increase in suburb-to-suburb and central city-to-suburbs commuting (Hamilton, 1982; Bookout, 1992; Hu and Young, 1992; Hughes, 1992; Rosetti and Eversole, 1993; Downs, 2004). In one case, longer average metropolitan travel times were associated with lower values of a composite variable that in part represented employment centrality (Ewing, et al., 2003). In another study low jobs-housing proximities in 1990 were associated with longer commute times in 2000 (Sarzynski, et al., 2006).

However, some previous studies based on the relationship between the decentralization of jobs and commuting may indicate that sprawl helps reduce commute lengths, especially in terms of time. In several cases it has been found that commute time to work is less in metropolitan areas where a greater percentage of metropolitan employment is located far from the central business district (Gordon, et al., 1989; Sultana, 2000; Crane and Chatman, 2003; Gordon, et al., 2004), or will be shorter for commuters to peripheral employment locations than in larger and denser urban centers (Dubin, 1991; Cervero and Wu, 1997; Sultana, 2000; Ma and Banister, 2006), regardless of whether this deconcentration is labeled as sprawl. There are several possible explanations for this shorter commute time. The first is that different kinds of jobs are found in sprawling areas than in urban areas. In one study it was found that commuting patterns varied by occupation (Crane and Chatman, 2003), with greater deconcentration of construction and wholesale jobs associated with shorter commutes, and longer trips to work appearing with less centralized manufacturing and government jobs. This is explained by the greater clustering of government offices and manufacturing firms, requiring longer commutes for their workers.

Another explanation is that households will seek to avoid additional commute times by changing their residence and/or workplace location. In addition, employers may also attempt to find new locations in less congested areas or near potential employees. This is known as the co-location or rational relocation hypothesis (Levinson, 1998). Clearly, if workers are willing and able to move closer to workplaces, or vice versa, commutes may remain at previous levels, or even decrease. Though there are many strong reasons to question the willingness and ability of households to relocate in response to changing job locations (Hanson and Pratt, 1988; Giuliano, 1989; Wachs, et al., 1993), the results at the metropolitan level do suggest this may be happening (Ma and Banister, 2006).

With these mixed theoretical and empirical views about the implications of decentralized growth, it is essential to investigate how job sprawl affects workers' commuting patterns at the intraurban level. At this scale sprawl would be represented as specific areas within a metropolitan area (based on a variety of criteria), and the relationship between sprawl and commuting would be identified as a difference in journey-to-work times or distance between sprawling and non-

sprawling areas within a metro area. Job sprawl can be expected to result in longer commutes for workers in the central city or inner suburbs who are forced to travel greater distances outwards to the periphery of the city, often on roads that do not allow high speeds. On the other hand, as at the metropolitan level, job sprawl may not make any difference for workers who have moved to peripheral areas. This possibility has been strongly suggested by a study of residential sprawl (Sultana and Weber, 2007) that indicated it is actually workers who commute from sprawling residential areas to urban jobs that have the longest commutes, while workers who travel between sprawl homes and jobs have the second lowest commutes (after those who commute entirely within urban areas). Defining sprawl by reference to workplace location may give a different result, and may also reveal the extent to which relocation is an option for workers.

Race and Commuting

Black suburbanization has increased substantially since the 1960s (Frey, 2001). However, the residential segregation of blacks persists, especially in central cities and older suburban neighborhoods, while jobs continued to decentralize to new suburban and exurban areas of metropolitan areas (Massey and Hajnal, 1995). Longer commutes have been observed for central city black residents traveling to suburban job locations (McLafferty and Preston, 1992, 1996; Johnston-Anumonwo, 2001; Chung, et al., 2001; Sultana, 2003, 2005a). These residents are not only forced to take longer trips to suburban employment, but they are also often at a disadvantage in entering the expanding suburban labor markets because of a lack of information about job vacancies and the cost of a job search far from home. They may also not be able to adjust their place of residence due to the various discriminations practiced against them in suburban housing markets (Martin, 2001).

Naturally, this raises the question of how employment sprawl may affect central city black commuters. Is sprawl a phenomenon that affects all people equally, or is it a spatial manifestation of larger issues that are tied to particular social groups? While the problem of transport in sprawl is often implicitly applied to a white middle class population, there is no reason to assume that this group is the most disadvantaged by changes in commuting patterns. One study measured job sprawl as the proportion of jobs located outside a five mile distance from downtown, and found that it was associated with higher spatial mismatches for black (but not white) workers in metropolitan areas with greater rates of employment sprawl jobs (Stoll, 2005). This indicates longer commutes for blacks to sprawling jobs, which clearly implies that sprawl reinforces the negative effects of job decentralization already observed for black workers. Central city decline and increasing poverty and unemployment may actually be an inevitable component of the urban sprawl growth process (Downs, 1999).

However, other findings suggest that sprawl may offer affordable housing and hence reduce the black/white housing ownership gap (Kahn, 2001), and there is evidence that suggests that black residents tend to be attracted to areas that are experiencing high job growth (Martin, 2004). This provides some possibility that sprawl will help shorten black commutes if black households relocate to preserve

reasonable commuting times to sprawling workplaces. This issue clearly needs to be examined.

Our study provides several significant contributions in understanding the process of workplace sprawl and its relationship with workers' commuting time. First, this paper uses a straightforward methodology to define and map employment sprawl at the intrametropolitan level, which can be used to study and map urban sprawl in other metropolitan areas. Second, commuting distance is calculated using both travel time and distance, allowing us to compare two distinct measures of journey to work patterns. Finally, race is incorporated into the discussion about the costs and benefits of sprawl and which groups will pay these costs.

STUDY AREA, DATA AND MAPPING SPRAWL

Study Area

The Birmingham, Alabama, metropolitan statistical area (MSA) is examined here to find the impact of job sprawl on commuting behavior (Figure 1).

This is a medium-sized MSA, with 921,106 people in four counties in 2000. However, full commuting data are only available for Jefferson and Shelby Counties, and therefore only these two counties are used here. Jefferson County contains Birmingham while Shelby represents the area of greatest suburban growth. Employment growth is well above the US average of 15.7 percent between 1990 and 1998, with Birmingham having a 205.2 percent increase in the number of jobs, almost all in Shelby County. In 2000 the city of Birmingham was 73.5 percent black, while suburbs in the highlands to the south of Red Mountain remain mostly white (Figure 2) (Ueland and Warf, 2006). One of these, Mountain Brook, has over 20,000 people with only 0.3 percent of the population being black. At a larger scale, Jefferson County is 39.4 percent black and Shelby County only 7.4 percent black (Remington, 2002).

Employment densities at the TAZ level in Birmingham reflect the area's industrial heritage as well as the freeway and suburban era (Figure 3). Jones Valley, to the north of Red Mountain, remains the area of highest job density, with peaks in Bessemer, Fairfield, and the downtown Birmingham/University of Alabama-Birmingham (UAB) area. Higher densities also extend north and south of the city along US 78, US 280, and I-65, including some major shopping centers and office parks.

Data and Methods for Extracting Selected Variables

The 1990 and 2000 Census Transportation Planning Packages (CTPP) were used to map job sprawl and to understand its implications for commuting. The CTPP is a census dataset collected by the U.S. Census Bureau from the census long form and distributed by the Bureau of Transport Statistics specifically for transport planning and research. It provides the most detailed data for commuting patterns in U.S. cities. The CTPP data are organized in three sections. Part 1 tabulates information by the place of residence of workers and households, while Part 2 includes information by place of employment such as location of employment and characteristics of workers. Part 3 shows origin-destination flows between home and work zones and the average time spent com-

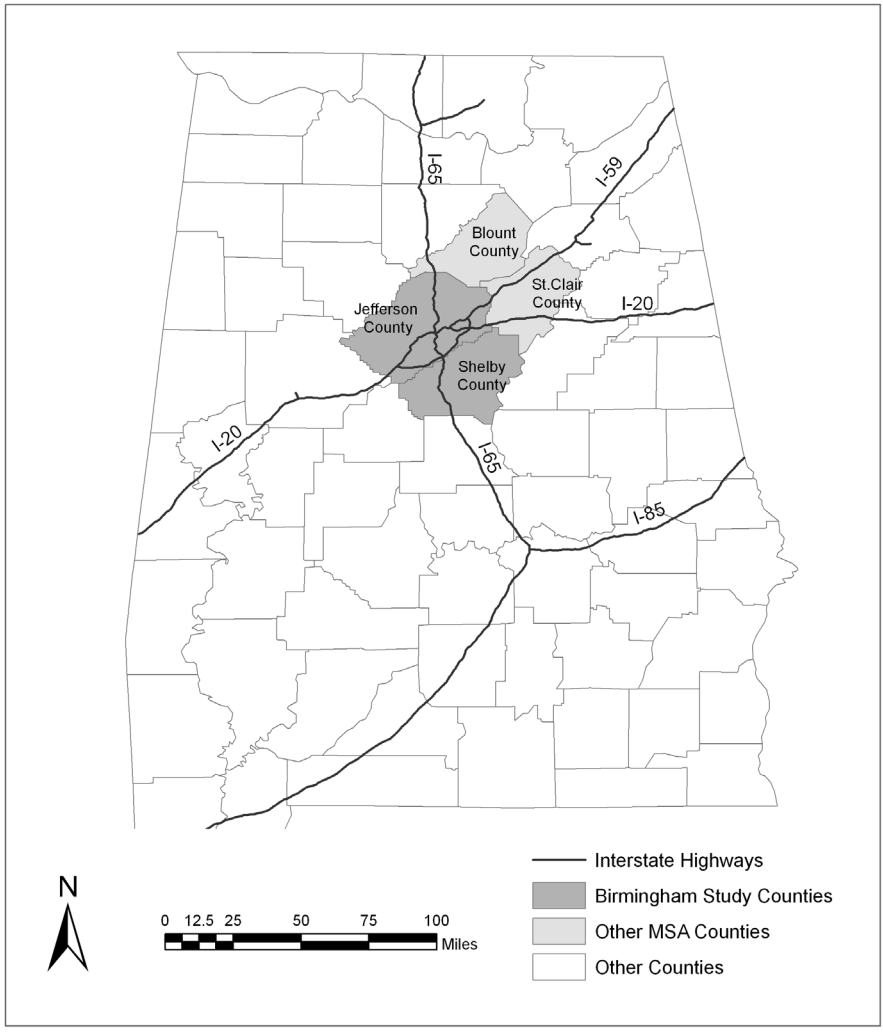

Figure 1. Location of Birmingham Study Area and Remainder of Four County MSA.

muting (while trips into and out of each MSA are included, these flows are not included in this research). In each case the data include information on commuting times, mode choice, time leaving home, vehicles available, and a wide range of socioeconomic characteristics of workers.

Part 2 provided the primary commuting variables for this research (Table 1). Both journey to work distance (miles) and time (minutes) were used, as each measures the separation between home and work differently (Wang, 2000). While the low-density environment of sprawl will likely increase commuting miles, travel time will show the effects of traffic con-

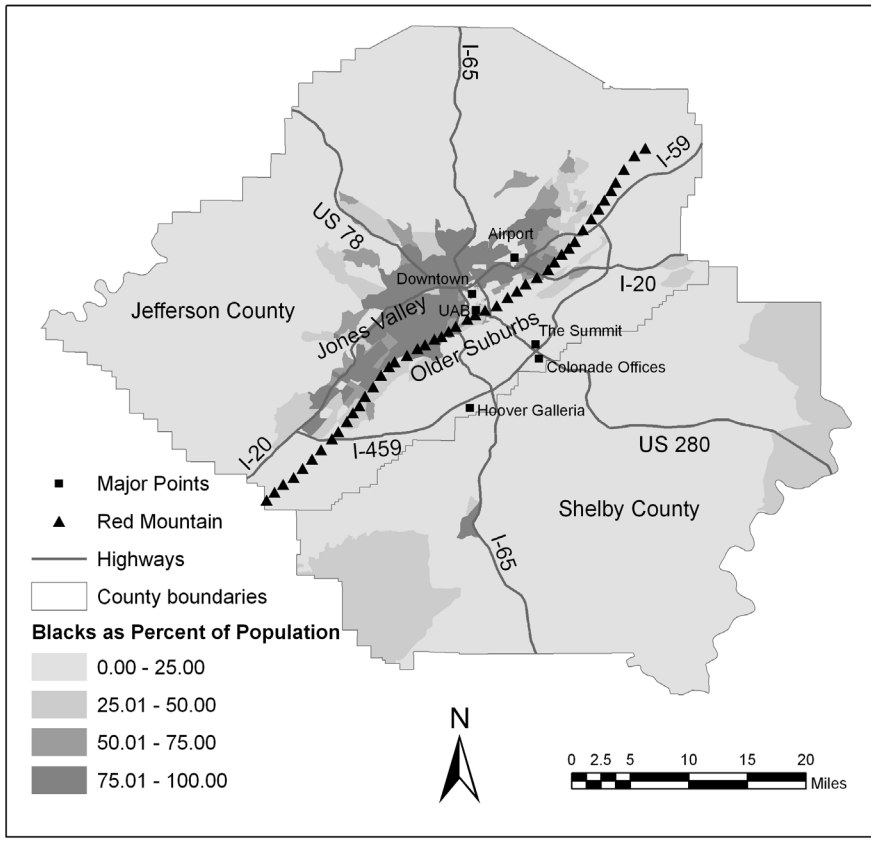

Figure 2. Distribution of Black Population in Birmingham MSA.

gestion and slow driving on local roads. However, since Part 2 does not include mileage traveled to work, this was obtained using Part 3 data, which include the number of people commuting between each pair of zones within the city. Shortest path mileages between zones were calculated within ArcView GIS using an Avenue script with TIGER street networks. The mileage between each pair of zones was then multiplied by the number of commuters traveling between each zonal pair, and then summed by the destination zone. The resulting value shows total miles traveled by workers to each zone, which is then divided by workers to get the average miles traveled.

Commuting times were also broken down by mode (drive alone, bus, and bike or walk) and race (black or white). It can be expected that the number of workers favoring transit or biking/walking will be greater for urban areas, while sprawl travel times will be longer. Travel times by race are not directly given in the CTPP, as they are only available for five-minute intervals. Average travel times for blacks and whites, therefore, are estimated by mul-

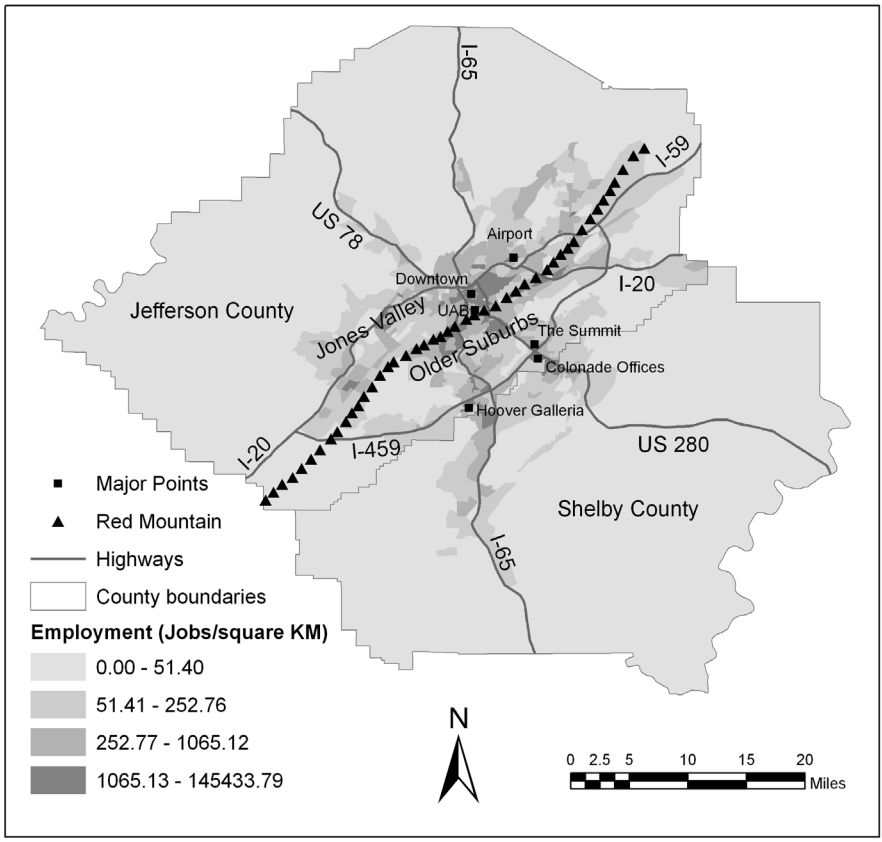

Figure 3. Employment Densities and Major Points in Birmingham MSA.

tiplying the number of black and white workers in each interval by the midpoint of the interval. Race does not appear in Part 3 of the CTPP, so it is not possible to match the origins and destinations of commuting trips of black and white workers (a minority coding does exist, but this has been suppressed due to small flow volumes).

Additional characteristics of commuters were included, including vehicle occupancy, percent leaving between 7 and 9 AM, and socioeconomic characteristics of workplace zones that can be expected to be useful in understanding commuting behaviors (e.g., Wiley, 1998; Sultana, 2005b). These include worker earnings and the percent of workers living below the poverty level. A wide variety of work has documented that higher income workers can be expected to travel farther to work (Sultana, 2000), and it is important to understand if sprawl increases or mitigates this pattern. Likewise, the racial composition of workplaces was included to see if travel time varies by race. The percentage working in each industry was also included, as certain kinds of jobs

Table 1. Workplace and Residential Variables

Workplace Variables	Workplace Variables
Average miles	Percent of workers in construction
Average time (minutes)	Percent of workers in manufacturing
Average drive alone time	Percent of workers in wholesale
Average bus time	Percent of workers in retail
Average bike/walk time	Percent of workers in transportation
Average white time	Percent of workers in information
Average black time	Percent of workers in finance
Percent drive alone	Percent of workers in professions
Percent use transit	Percent of workers in education
Percent bike/walk	Percent of workers in arts and entertainment
Percent of whites driving alone	Percent of workers in other services
Percent of whites using transit	Percent of workers in public administration
Percent of whites biking or walking	Percent of workers in armed forces
Percent of blacks driving alone	Residential Variables
Percent of blacks using transit	
Percent of blacks biking or walking	Population density (per square km)
Average per vehicle	Household density (per square km)
Percent leave during rush	Housing density (per square km)
Job density (jobs per square km)	Percent of residents who own home
Percent of workers who are white	Average income of residents
Mean earnings ($)	Percent of residents who are white
Percent below poverty	Percent of residents who drive alone
Percent of workers in agriculture	Average travel time of residents

may be expected to appear in particular areas (Crane and Chatman, 2003). For example, manufacturing jobs have traditionally been found within the Birmingham urbanized area but have recently been spreading into previously rural areas of the state. This variable should therefore reveal the extent to which sprawl has had a commuting impact on a significant industry (though CTPP data does not allow direct comparison of travel times by occupation or industry).

A final set of variables was added to examine the relationships between the commuting characteristics of local residents and workers coming to that zone. There has been considerable interest in recent years in investigating how residential characteristics can affect commuting behaviors such as mode choice and trip length (Boarnet and Crane, 2001). While this usually focuses on the residential end of the trip, characteristics of the destination end such as population or job density have also been shown to have an effect on travel behaviors such as mode choice (Zhang, 2004). Comparing residential and commuter characteristics will also allow additional identification of whether sprawl workers are suffering from disparities.

Commuting variables from Part 1 (commuting characteristics of residents in each TAZ) were therefore included, including commuting times, mileages, mode choice, population and housing densities.

Mapping Sprawl

We followed Sultana and Weber's (2007) approach to map employment sprawl for Birmingham metropolitan area. Employment sprawl is defined here as an urban growth process with high rates of job growth and low employment densities, and that takes place outside the built-up areas of the city. The Urbanized Area (UA) is again used to define the built up areas in a way that avoids political jurisdictions or a problematic city/suburb distinction. Sprawl in Birmingham was mapped as those areas within the MSA but outside the UA boundary that have above average employment growth (16.23 percent), and below average job density (83.71 jobs per square kilometer). This paper therefore examines commuting at a larger spatial scale than that between city and suburb, that more appropriately reflects contemporary urbanization.

Sprawl was identified and mapped at the level of Traffic Analysis Zones (TAZs), which are small areas aggregated from census blocks. To calculate employment growth, 1990 TAZ boundaries (not included with the 2000 CTPP) were reconstructed from 1990 census blocks using an index file provided with the 1990 CTPP (which is no longer functional on most PC operating systems). However, the 1990 and 2000 TAZs frequently have different boundaries, so 1990 employment values were transferred to 2000 zones by interpolating them to a raster grid (with 100 meter cell resolution), and then overlaying the 2000 TAZs on to this surface. The percentage change was then calculated.

Employment sprawl is widespread across Birmingham (Figure 4), though only 8.12 percent of jobs (or a total of 33,705 jobs) in the metropolitan area are located in sprawl areas. The majority of Shelby County is included, which is not surprising as this is the fastest growing county in the state. In Jefferson County sprawl is especially evident in the western end of the county. Growth along US 78 follows urbanization in this direction, as it does to the north and east. However, there remain many scattered areas where little growth has occurred, in some cases immediately adjacent to the UA. This reflects steep terrain and the presence of abandoned mines in many of these areas.

FINDINGS

Commuting to Urban vs. Sprawl Jobs

Analysis of Variance (ANOVA) was used to see whether there are significant differences in commuting times and distances of workers (by means of transport) between urban and sprawl areas jobs (Table 2). Surprisingly, the average travel distance to work is actually significantly shorter to sprawl zones (by about 3 miles). These findings differ from that found for residential sprawl (Sultana and Weber, 2007), but are consistent with Crane and Chatman's (2003) findings that higher levels of sprawling employment are associated with shorter commutes at the metropolitan level. As in their study, employment sprawl results in workers being closer to jobs, resulting in shorter commute distances to sprawl workplaces. However, the absence of differences in

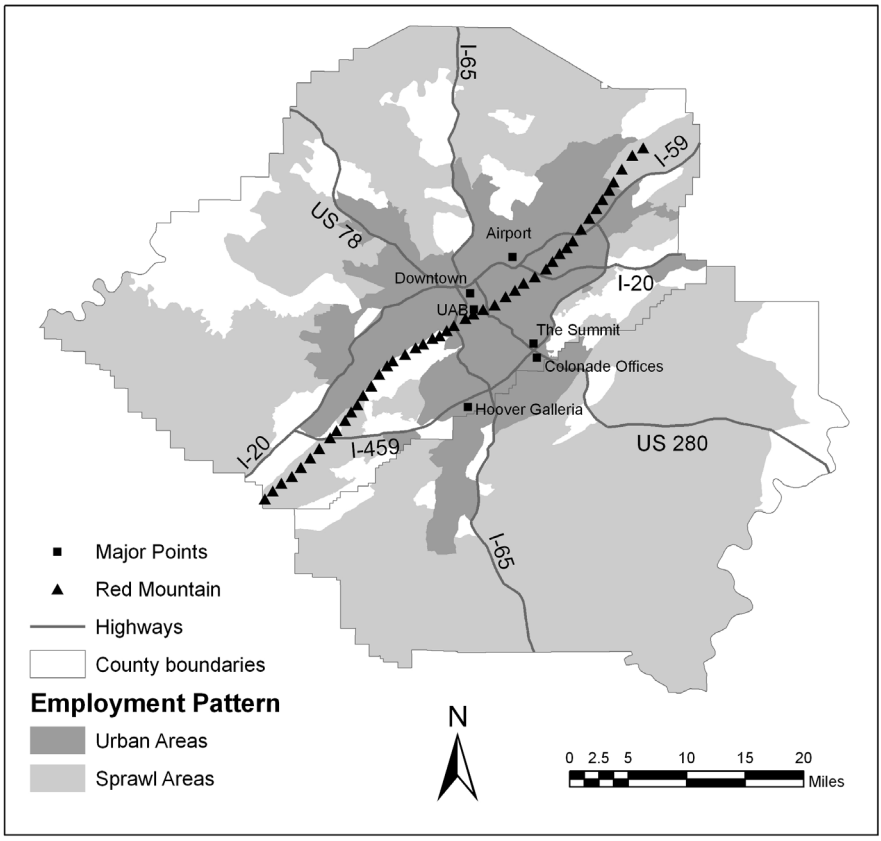

Figure 4. Employment Sprawl in Birmingham MSA.

commuting times between urban and sprawl jobs means that travel speeds are slower in sprawl areas, likely due to the reliance on low-speed rural roads (Crane and Chatman [2003] were unable to examine travel times in their study). The results are also consistent with the co-location hypothesis that workers will relocate to maintain or minimize their commute length, although it cannot directly confirm this.

Mode choice reveals some surprising distinctions between urban and sprawl commuting. Average travel time and commute time by driving do not show any significant differences, which in itself may also be surprising. Transit times are greater for urban workplaces in Birmingham, while commuting time by walkers or bikers is significantly less for sprawl jobs. Commuters to sprawl areas are less likely to commute solo in a car, and sprawl workers have slightly higher vehicle occupancy rates. Similarly, workers are more likely to use bikes or walk to work in sprawl jobs, which is in contrast to common expectations about dependence on cars in sprawl. However, these results are

similar to the case of Atlanta where it was found that ride-sharing is not necessarily negatively related to less dense suburban employment centers (Sultana, 2000; 2002a). It could be that large employers in sprawl areas allow for greater carpooling, or social networks are more important in low-density areas than in cities.

However, when travel times and mode choice are examined by race, an important difference emerges. Average travel times for white workers are significantly shorter to sprawl jobs than to urban jobs, while there is no difference in black times. Also, whites are more likely to drive to urban jobs, and are actually more likely to bike or walk to sprawl jobs than urban jobs. No significant differences exist for black workers' mode choice between urban and sprawl jobs.

The socioeconomic characteristics of workers show some variations as well, with sprawl jobs being occupied by a higher percentage of white workers. Average worker earnings are about $3,300 higher for jobs in urban areas, indicating that higher paying jobs remain in older parts of the city. Manufacturing job locations show no significant variation between urban and sprawl, showing that the presence of large industrial facilities in central Birmingham has been offset by rapid growth in manufacturing outside of older industrial areas. Agricultural, construction, and finance jobs do show significant differences in their distribution, with the first two being more common in sprawl areas, which can be expected given the nature of these industries.

The characteristics of residents near job sites are associated with commuting to those jobs. Sprawl jobs are located in TAZs where homeownership predominates, and the average income of local residents is far higher than that of people living near large numbers of workplaces in urban areas. Sprawl workplaces also tend to be located in almost entirely white areas, however the racial composition of workers is not nearly as unbalanced as the racial composition of urban residents. Residents near sprawl employment areas are far more likely to drive alone to work in Birmingham, and have much higher travel times than urban residents. Population, household, and housing densities are not surprisingly much lower than in urban areas.

Regression Models Explaining Commuting Behavior of Workers by Workplace Locations

While there are clearly many significant differences among commuters to jobs located in urban and sprawl areas, the comparisons of averages do not show interactions between variables, and hence we can not determine the extent to which individual variables influence the dependent variable. To explore these questions, stepwise multiple regression was used with mileage and travel time measures as dependent variables. A range of independent variables extracted from Part 2 of the CTPP at the TAZ level were used as explanatory variables, reflecting commuting choices as well as socioeconomic characteristics of workers that can be expected to have an influence on commuting (Weber and Kwan, 2003; Sultana, 2005b). A dummy variable representing whether a zone was identified as employment sprawl was included. The regression models are shown in Table 3. The models only included those predicted variables that are free from multicolinearity and are statistically significant.

Table 2. Commuting Differences by Place of Work

Variable N	Urban 637	Sprawl 84	sig.
Average miles	9.28	6.05	0.000
Average time	27.38	26.32	0.232
Average drive alone time	26.37	25.70	0.457
Average bus time	13.24	6.19	0.025
Average bike/walk time	5.72	2.55	0.067
Average white time	28.87	24.60	0.000
Average black time	22.99	24.28	0.309
Percent drive alone	80.15	73.21	0.000
Percent use transit	0.96	0.40	0.081
Percent bike/walk	1.42	2.92	0.001
Percent of whites driving alone	84.28	73.85	0.000
Percent of blacks driving alone	74.57	70.21	0.135
Percent of whites riding bus	0.12	0.21	0.361
Percent of blacks riding bus	2.41	1.32	0.253
Percent of whites biking or walking	1.38	3.04	0.002
Percent of blacks biking or walking	3.01	3.15	0.882
Average per vehicle	1.08	1.11	0.012
Percent leave during rush	43.41	36.36	0.000
Job density	3211.91	16.38	0.009
Percent of workers who are white	67.80	85.68	0.000
Mean earnings	33244.12	29901.19	0.048
Percent of workers in agriculture	0.28	3.69	0.000
Percent of workers in construction	7.42	19.34	0.000
Percent of workers in manufacturing	7.68	10.29	0.104
Percent of workers in wholesale	4.61	3.97	0.569
Percent of workers in retail	12.34	10.58	0.341
Percent of workers in transportation	5.17	5.82	0.645
Percent of workers in information	2.91	1.10	0.071
Percent of workers in finance	8.61	2.50	0.000
Percent of workers in professions	9.64	8.57	0.480
Percent of workers in education	20.12	16.74	0.226
Percent of workers in arts and entertainment	6.84	6.72	0.935
Percent of workers in other services	7.84	8.44	0.639
Percent of workers in public administration	3.88	2.83	0.411
Percent of workers in armed forces	0.21	0.07	0.564
Percent below poverty	6.72	5.78	0.262
Population density	947.56	69.45	0.000
Household density	392.52	25.17	0.001
Housing density	477.53	26.76	0.004

Table 2. continued

Variable N	Urban 637	Sprawl 84	sig.
Percent of residents who own home	47.59	88.77	0.000
Average income of residents	38909.63	67332.18	0.000
Percent of residents white	42.40	93.54	0.000
Percent of residents who drive alone	61.39	86.61	0.000
Average travel time of residents	17.71	29.46	0.000

Shading indicates no significant commuting differences at p=.05 or better.

The results show that job sprawl is the second most influential variable that significantly reduces workers' commuting mileage in Birmingham. However, it is again not related to commuting time for all workers. Transit usage and higher vehicle occupancies are positively associated with longer travel times in Birmingham, as was expected from past commuting research (McLafferty and Preston, 1996; Sultana, 2002b). However, biking and walking are negatively associated with commuting time, suggesting again that people are more able or likely to walk or ride a bike if the duration of the commute is shorter. Higher dependency on driving alone is the most influential variable that leads to longer commute mileages, while carpooling adds to both commute length and time.

When models for black and white workers are run separately to understand how similar or different variables are related to their commute time, the results show considerable differences (columns three and four in Table 3). Our model shows clearly that sprawl increases commuting time for black workers, though this does not have any effect on white workers' commuting time. Although no difference was found for black workers using ANOVA, it is greater for sprawl workers when mode choice was controlled for in the regression model. This indicates that there is a difference, but mixing in multiple modes, as in the ANOVA, concealed this. Again a high rate of car usage is associated with longer commute times for both blacks and white workers; however, this variable has a stronger effect on black workers (0.53) compared to white workers (0.23). Increased transit use is associated with longer travel times for black workers but not for white workers, which is also found in the neighboring metropolitan area of Atlanta (Sultana, 2005a). In contrast, even though higher vehicle occupancy increases commuting time for both groups of workers, it has a more negative effect on white workers. The percentage biking and walking does not appear for either group, though black workers were found in the ANOVA testing to be more likely than whites to use these modes. These findings are broadly consistent with earlier findings and the spatial mismatch hypothesis that has found modal differences and longer commutes for black workers (Johnston-Anumonwo and Sultana, 2006).

The absence of sprawl as an explanation for white workers' commuting time can be explained by the other variables

Table 3. Regression Results

Variable	Miles	Time	Black Time	White Time
Adjusted R^2	0.225	0.222	0.367	0.247
Constant	−4.456	8.805	−5.507	2.776
Sprawl dummy	−0.279		0.103	
Percent drive alone	0.330			
Percent use transit		0.195		
Percent bike or walk		−0.199		
Percent of blacks who drive			0.528	
Percent of blacks who ride bus			0.398	
Percent of blacks who bike or walk				
Percent of whites who drive				0.232
Percent of whites who ride bus				
Percent of whites who bike or walk				
Percent leave during rush				
Average workers per vehicle	0.160	0.241	0.150	0.213
Job density				
Mean earnings	*0.075*	0.113		0.106
Percent below poverty		−0.148		−0.132
Percent white	*0.084*			−0.257
Percent of workers in manufacturing	0.112	0.250		0.241

Shading indicates variables that are not applicable for a model, blanks indicate variables that did not appear in a model. Italics indicate variable significant at .05; all other variables are significant at .01.

that show the economic status of workers. Higher incomes make for longer commutes by both time and mileage, as well as for white workers, which has also been found in other research (Hazans, 2004; Sultana, 2002b). This is consistent with ANOVA results showing higher earnings and longer commutes to urban areas. Similarly, higher poverty levels are associated with lower commute times, especially for white workers (though poverty levels are not statistically different between sprawl and urban areas). It is interesting that poverty appears in both models for which sprawl does not have any explanatory power.

Similarly, increased manufacturing employment adds to commute mileages and times (except for blacks), which is consistent with past studies (McLafferty and Preston, 1996), although ANOVA testing showed no difference in manufacturing employment between sprawl and urban areas. Also, commute times for white workers are shorter to job locations that have a higher percentage of white workers, though average travel mileage increases for all workers where higher percentages

of white workers are concentrated. This is consistent with all urban workers having longer mileages but white workers having shorter travel times to sprawl jobs. It is not surprising that socioeconomic variables do not appear in the model for explaining black workers' time, as these have been found to be less important in other studies (Sultana, 2005a). Instead, mode choice (and vehicle occupancy) and sprawl explain variations in the commuting time of black workers. This is because the black population remains concentrated within the urbanized area, and hence, black households may not become sorted out by socioeconomic differences as white households have.

Several other variables are absent from the models. The percent of workers leaving during rush hour does not show any effect on commuting time for any model, though this variable has been found elsewhere to be a significant influence in other cases (Sultana, 2005b). Job density also does not appear, undoubtedly due to it already being measured at a categorical level by the sprawl dummy in two of the models. However, it is striking that while there is a huge difference in average job densities between urban and sprawl, it makes no difference to commuting times or mileages.

DISCUSSION AND CONCLUSIONS

Although common notions that sprawl is associated with a longer journey to work have been confirmed when measuring residential sprawl (Sultana and Weber, 2007; Sarzynski, et al., 2006), they are not always apparent for employment sprawl. Using the most detailed commuting data available, our results show that travel times to work, which are perhaps the most basic indicator of sprawl impacts on commuting in this country, do not show any difference between jobs located in sprawl or urban areas in Birmingham. Employees at sprawling job locations cannot be assumed to have longer commutes or be more automobile dependent than workers in more established urban settings. Further, when mileage is used as a measure of commute distance, it is actually workers in sprawling areas who drive shorter distances and are less likely to drive alone. These results match findings from the metropolitan level that show that higher levels of suburbanized employment are associated with shorter commutes (Crane and Chatman, 2003), although in that case it was average commuting increases over time (between 1985 and 1997) that were measured, while this research examines differences in average commuting length within a metropolitan area for one point in time (2000). These two approaches nonetheless show very similar results.

However, the possibility of shorter commutes also does not apply equally to black and white workers. While sprawl employment reduces times for whites, it increases it for black workers, who remain concentrated in the central city of Birmingham and so are unlikely to live close to sprawl jobs. Not surprisingly, job sprawl may result in increased spatial mismatch for black workers if they do not adjust their residential location (Stoll, 2005). The possibility of workers relocating to maintain reasonable commutes only exists if workers actually have the opportunity to relocate, and the freedom of people to live wherever they please in Birmingham has

required a long and often violent political struggle (Wilson, 1985, 1989, 2000; McWhorter, 2001; Connerly, 2002).

As in most American cities, rational relocating here once referred to whites moving away from blacks rather than households moving out of a desire to maintain or reduce commuting distances. Regardless of the motive for relocating among white households today, it does not appear to be a simple option for most black workers, and will not likely continue be one in the near future (Downs, 1999). There is also the question of whether blacks even desire to move to sprawling areas, as they may want to remain within black neighborhoods, even if they are more economically similar to residents of white suburbs (Wilson, 1985). The potential benefits to relocating to outlying areas may be lost if a household's social network is lost. For these reasons the negative impacts of sprawl to black workers can be expected to increase in the future.

This paper shows that the type of sprawl being discussed makes a significant difference to commuting at the intraurban level. Employment sprawl may differ greatly in location and extent from sprawl defined by reference to housing or population patterns. Therefore, the impact of sprawl on commuting behaviors must clearly take into account not just residential location but also the employment end of the commuting trip. Living in a New Urbanist community may have little effect on an individual's mode choice or travel time if that person commutes to an automobile factory located many miles outside the city, adjacent to a freeway interchange and not much else. However, the possibility that job sprawl may help reduce commuting is contingent on the urban growth process. As the definition of sprawl used here is based on areas of rapid growth and low density, it is likely that continued growth will necessitate the reclassification of zones from sprawl to urban. It is uncertain what will happen to commuting in those areas in the future, though the expectation of rational relocation would require workers (or jobs) to continue moving (though not necessarily farther out) to maintain reasonable commutes.

The methodology and data used here can readily be extended to other metropolitan areas, with due regard for the technical difficulty of extracting data from the 1990 CTPP. As sprawl is an areal characteristic, the Modifiable Areal Unit Problem (MAUP) is an inherent concern. Measuring sprawl for other common zones can be expected to give a different result, though discussions of sprawl are much further from assessing these impacts as with other transport topics (Sultana 2002b, Horner and Murray 2002). There are clearly also many temporal relationships between sprawl and commuting that need to be examined (Sarzynski et al 2006). Do people relocate to be closer to sprawling jobs, or choose new jobs in sprawling areas, to maintain or reduce their commuting times? Or do jobs relocate to sprawl areas (or new firms prefer to locate in sprawl) to lower costs or attract workers? The fact that the definition of sprawl used here refers to areas of high employment growth actually favors the notion of employment relocation. However, any further answer regarding the effects of sprawl on commuting requires the resolution of the question of how recently workers have moved to their cur-

rent home, or even how many want to move (or can move), and to where.

It should also be noted that there is no commuting time or distance data by industry or occupation and even fewer data are available by sex. Parts 1 and 2 of the CTPP do not include travel times by sex, and Part 3 does not contain any data by sex, so the question as to what extent differences in commuting times and distances between urban areas and sprawl are being influenced by gender differences in commuting cannot be examined directly. Neither can household structure be examined using the CTPP, although this is another issue of critical importance for understanding the current and potential future impacts of sprawl (Sultana, 2006). The 5 percent Public Use Microdata Sample (PUMS) allows each of these variables to be distinguished, but it does not allow spatial analysis of commuting at a fine scale, as data are available only for defined areas of 100,000 people or more (Sultana, 2005b).

Finally, it must be kept in mind that commuting trips make up only about 25 percent of weekday trips (Horner, 2004). Regardless of the relationships between sprawl and commuting, there are many other types of travel that must be examined to fully understand the interactions between sprawl and traffic congestion. Discretionary trips made to shop, bank, eat, be entertained, deliver and retrieve children, or engage in a variety of other activities in areas that can be identified in sprawl must also be examined and could clearly take on multiple possible relationships with sprawl (however it is measured). This is unfortunately not possible with the CTPP, so other data will be necessary to understand the full impacts of sprawl on travel behavior.

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